Globalization and WMD Proliferation Networks: The Case of Unmanned Air Vehicles as Terrorist Weapons

Strategic Insights, Volume V, Issue 6 (July 2006)

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Strategic Insights is a bi-monthly electronic journal produced by the Center for Contemporary Conflict at the Naval Postgraduate School in Monterey, California. The views expressed here are those of the author(s) and do not necessarily represent the views of NPS, the Department of Defense, or the U.S. Government.

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Introduction

The historical handmaiden of warning ambiguity is the tendency of strategic planners to obsess over familiar dangers at the expense of more likely ones.

Likely threats appeared to clash with more familiar ones when, just four months after 9/11, the Central Intelligence Agency (CIA) released the National Intelligence Estimate on the ballistic missile threat to the United States. In it, the intelligence community argued that the United States is more likely to be attacked with weapons of mass destruction (WMD) using “ships, trucks, airplanes or other means” than with an intercontinental range ballistic missile.

The 2002 National Intelligence Estimate (NIE) also stated that cruise missiles launched from forward areas—the most plausible scheme being the use of a covertly equipped commercial vessel—offer an adversary better alternatives than ballistic missiles.[1] Although the intelligence community had state actors principally in mind, terrorists and non-state actors have also figured into American planning. In a 2001 counter-terrorism exercise, North American Aerospace Defense Command (NORAD) simulated a cruise missile launch from a merchant ship in the Gulf of Mexico, which led the NORAD test director observed, “we are naked … [and] have no capacity to deal with that kind of problem.”[2]

Of course, it’s one thing for a state—possessing all the necessary engineering skills and experience—to produce and furnish an armed, unmanned air vehicle (UAV) or cruise missile to a terrorist group. Just such a linkage was purported to exist between Iraq and al Qaeda, at least according to the Bush administration, in early 2003.[3] And Iran appears to have furnished the terrorist group Hezbollah with their unarmed Mohajer-4 UAV, which was flown over northern Israel in November 2004 and April 2005, both times surprising and embarrassing Israeli air defenses.[4]

Yet to suppose that a sub-national terrorist group, on its own, could develop such a delivery system deserves closer scrutiny.[5] Certainly, a terrorist group could take advantage of the last decade’s quantum leap in dual-use technologies that comprise the chief components of autonomous air vehicles. These include satellite navigation and guidance furnished primarily by

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
JUL 2006		**00-00-2006 to 00-00-2006**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Globalization and WMD Proliferation Networks: The Case of Unmanned Air Vehicles as Terrorist Weapons	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Postgraduate School,Center for Contemporary Conflict,1 University Circle,Monterey,CA,93943**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**14**	

the U.S. Global Positioning System (GPS), high-resolution satellite imagery from a growing number of commercial vendors, and digital mapping technologies for mission planning. Indeed, the presumption that virtually any person or small group with the appropriate knowledge and skills could build a simple, autonomous, self-guided cruise missile with a significant payload is increasingly becoming the conventional wisdom.

To examine the possible use of UAVs or cruise missiles as terrorist weapons, this article approaches the subject from two principal angles: motivations and capabilities. To be sure, possession of the requisite "knowledge and skills," together with easy opportunities to procure all the component parts, represents a necessary, but not sufficient, condition of this examination. All too frequently, proliferation questions are addressed from the standpoint of raw technological determinism. A more complex web of planning motivations and technological factors inform whether or not terrorists will successfully pursue the use of UAVs or cruise missiles to achieve their objectives.

After considering motivations, the article turns to capabilities by examining two possible and relevant scenarios of terrorist use of UAVs or cruise missiles: conversion of an anti-ship cruise missile for launching from an off-shore freighter, and transformation of a simple airplane into an unmanned means of achieving mass casualties.

The article concludes with a consideration of international responses, both military and non-military, to the challenges identified.

Planning Motivations

Scholars and counterterrorism practitioners alike now believe that a new form of religiously motivated terrorism has emerged, one that is unconstrained by the level of violence it seeks to achieve. This new brand of terrorism—unlike that practiced by ethno-nationalist terrorist groups such as the Irish Republican Army or Palestine Liberation Organization—is not amenable to diplomatic persuasion or political compromise. Its use of violence is designed not to secure a place at the bargaining table, but to destroy an existential adversary with whom bargaining is impermissible for theological reasons.[6] For those inclined toward this new brand of terrorism, there exists a complementary relationship between apocalyptic aims and weapons of mass destruction.

Religiously motivated groups consider WMD the preferred means of killing, almost without regard to the challenges entailed in acquiring such weapons. Take, for example, the perverse Japanese cult, Aum Shinrikyo, that pursued both biological and chemical agents. It easily could have killed more people using conventional explosives than it managed in 1995 with its clumsy use of sarin gas in a Tokyo subway.[7] When it had failed to achieve any success pursuing biological agents, it turned to producing chemical, rather than conventional, weapons to achieve its apocalyptic aims.

The evidence that al Qaeda is seeking WMD, while largely inferential, is nonetheless compelling. The Clinton administration attacked the Al Shifa pharmaceutical plant in Khartoum, Sudan in August 1998. However sullied by the controversy over this attack, the existence of covertly collected forensic evidence, together with the eventual testimony of Jamal Ahmed al-Fadl—a prosecution witness in the February 2001 trial for the bombings of two American embassies in East Africa—suggests a strong probability that al Qaeda was involved in producing chemical weapons in Sudan.[8]

Even more convincing was the testimony of Sultan Bashiruddin Mahmoud, a former nuclear scientist at the Pakistan Atomic Energy Agency. He set up and used a non-governmental organization (NGO) in Kabul, the Islamic Reconstruction, as a vehicle to visit Afghanistan

frequently between 1998 and 2001. Mahmoud finally admitted to his CIA interrogators that he met with Osama bin Laden and other al Qaeda members for two to three days in August 2001 to discuss WMD. Bin Laden was interested in nuclear, biological, and chemical weapons and sought advice on how to build a “dirty bomb” to spread radiological debris; the source of the radiological materials was expected to be the Islamic Movement of Uzbekistan. A subsequent search of Mahmoud’s NGO offices in Kabul uncovered a history of efforts to obtain anthrax, documents on the U.S. military’s immunization program, gas masks, and diagrams of an aerial balloon system for dispersing biological or chemical agents.[9]

There is strong evidence that the terrorists who planned and executed the September 11, 2001 attacks on New York and Washington had investigated the use of crop dusters as terror weapons. After the 9/11 attacks, Zacarias Moussaoui, the so-called 20th hijacker, was arrested in possession of a crop dusting manual.[10] The plot’s ringleader, Mohammed Atta, made several visits to a crop dusting airfield in Florida where he asked about the speed and range of such aircraft and the volume of chemicals they could hold.[11] In May 2000, Atta even attempted to secure a $650,000 U.S. Department of Agriculture loan, purportedly to start a crop dusting business. He told the Florida agricultural official that he wanted to use the money to purchase a six-seat, twin-prop crop duster. He intended to remove the seats so as to fit a large chemical tank inside the aircraft, leaving space for only the pilot.[12]

A pilot willing to die would certainly be needed to guide an unstable crop duster to its intended target. There is an intense fascination with suicide among religiously motivated terrorists—and jihadists in particular—which combines an element of romanticism with sacrifice and exculpation. However seductive this emotion, there is also a strong interest in attack effectiveness.

Employing a suicide pilot to guide an airplane to its desired target seems to be integral to achieving mass casualties. Yet, an aerial balloon does not require a suicide pilot to guide it. Although balloon delivery of biological agents was investigated during the early years of the U.S. biological weapons program, it is not a very effective way to disseminate agents.[13] Conversely, UAVs and cruise missiles are ideal platforms to deliver such agents.

The flight stability of aerodynamic UAVs and cruise missiles permits them to release and spray agents along a line of contamination.[14] Modeling indicates that these vehicles enlarge the lethal area for biological agents, conservatively, by a factor of ten when compared with ballistic missile delivery.[15] Radiological dispersal—an acknowledged area of al Qaeda interest—over large urban areas can also be effective with a UAV, but only if the source material is cesium chloride—the one radiological source that comes in a powered form.[16] While such radiological dispersal would not truly measure up to the destructive damage of other WMD, it would play on the public’s fear of anything radiological and cause long-term disruption.

Finally, the intended target’s vulnerabilities are critically important planning factors. Surely, that is what compelled al Qaeda to hijack large commercial airliners and effectively turn them into cruise missiles. The abysmal state of U.S. defenses against low-flying UAVs and cruise missiles invites terrorists to focus on acquiring them as terror weapons.[17]

A July 8, 2004 House of Representatives hearing drew grim attention to the lax state of defenses against low-flying objects by examining the near-catastrophic circumstances surrounding the June 9, 2004 funeral for President Ronald Reagan. As officials gathered in the Capitol, a combination of human error, onboard technical malfunction, and computer incompatibility between the Federal Aviation Administration (FAA) and the Transportation Security Administration (TSA) caused security personnel to mistake the governor of Kentucky’s official airplane as a terrorist threat. This led to the evacuation of hundreds of officials, the dispatch of two F-15 interceptors, and circumstances that nearly prompted the top general of NORAD to order the governor’s plane shot down.[18]

This near disaster in Washington, D.C. underscores the inadequacy of the nation's capacity to identify friend from foe. Each year, thousands of small private aircraft continue to wander into restricted air space around Washington, D.C.[19] In the case of the governor's plane, this led to erring on the side of caution. But the fact that a disastrous mistake nearly ensued could produce an even more tragic result: inaction in the face of a genuine terrorist threat. In any event, the head of the U.S. Department of Homeland Security's directorate in charge of air defense has admitted that the current system may not be able to stop a determined adversary.[20] An intelligent and committed terrorist is unlikely to fly a small airplane, whether manned or unmanned, above 3,000 feet, the altitude at which the FAA's radars would be able to detect and query the aircraft's transponder to establish its intentions. Clearly, terrorist use of an aircraft or UAV would present severe warning, detection, and interception challenges.

Technological Factors

The notion that just about any person or small group could build, at minimal expense, a simple, self-guided cruise missile based entirely on off-the-shelf component technologies deserves some examination. This proposition was given light during 2003 by a New Zealand engineer, Bruce Simpson, who created a website with the sobriquet "Do-It-Yourself Cruise Missile."[21] His objective was to document (and publish) his progress in building a simple cruise missile in his garage for under $5,000. Before having the chance to test his product, the New Zealand government, under pressure from the United States, forced Simpson to shut down his project. Simpson told BBC News that he had nevertheless proved "that by using off-the-shelf technology in a suburban garage a terrorist can create a weapon against which there is no effective defense."[22]

But before too much is made of do-it-yourself cruise missiles, it is important to note that it is by no means clear that Simpson's efforts would have proven successful. Just because individual component parts are available from commercial vendors does not mean that they can readily and successfully be integrated to produce a reliable system. Such a notion smacks of technological determinism or a simple reductionist viewpoint, whereby technology diffuses easily and smoothly into complex systems. A more plausible explanation for achieving success with any military system—no matter how simple it may appear on the surface—hinges on the possession of certain tacit knowledge skills. In the case of a cruise missile, system engineering or integration skills are essential to integrate actuators and servo mechanisms that are crucial for moving the cruise missile's control surfaces based on commands from a flight management computer. Simpson's technical approach to the flight management task mistakenly implied that system integration can be accomplished easily and reliably.

Two Scenarios

Two particular scenarios of relevance to possible terrorist use of UAVs are worthy of examination. Besides differing in their complexity of development and execution, they diverge in their launch points of origin.

The first entails launching a converted anti-ship cruise missile—transformed into one capable of flying over land—from a covertly equipped commercial vessel against a U.S. city or other target. Thus, the missile threat would emanate from outside of U.S. borders and face whatever aircraft NORAD could muster in time—assuming that such a low-flying missile were detected in the first place. The $10 billion a year that the United States spends on defenses against ballistic missiles does nothing to address this threat.[23] This scenario roughly equates to the one simulated in the 2001 NORAD counterterrorism exercise and also stated in the 2002 NIE (albeit in the state-actor context).

The second scenario focuses on converting a small aircraft into an armed UAV and launching it from a domestic point of origin against its intended target. Like al Qaeda's exploitation of lax airport security on 9/11, this case would exploit extant shortcomings in U.S. capabilities to detect and intercept threats flying under the FAA's radar system. Indeed, terrorists seem to be adjusting to 9/11's positive effects on airport security. According to the director general of intelligence for Canada's armed forces, terrorist groups have already purchased ultra-light aircraft and hang-gliders to work around effective security precautions against hijacking large commercial airliners.[24]

Scenario 1: Using Offshore Cruise Missiles

The possibility of terrorist involvement in a cruise missile scenario is not purely hypothetical, nor is it based only on the NORAD counterterrorism exercise. According to two former National Security Council (NSC) staff members, al Qaeda is believed to possess 15 freighters.[25] This has raised concern that terrorists could manage to acquire, deploy, and successfully launch a cruise missile from just outside U.S. waters using a freighter as the launch platform. But such a proposition, fortunately, faces a number of obstacles.

Rather than building a cruise missile from scratch, a more sensible approach would be to convert one of many widely available anti-ship cruise missiles, a proliferation course that Iran is currently thought to be following and one that Iraq attempted prior to the second Gulf War in March 2003. In Iran's case, it is reported to be upgrading around 300 Chinese HY-2 Seersucker anti-ship cruise missiles by fitting them with turbojet engines and new guidance systems.[26] Using surplus Chinese missiles has certain important advantages, not least of which is their wide availability. From a weapons proliferation standpoint, Seersucker/Silkworm[27] anti-ship cruise missiles share the Scud ballistic missile's ubiquity. They are available globally, even in such countries as Bangladesh, the Democratic Republic of Congo, Dubai, Egypt, Iran, Iraq (until 2003), North Korea, and Pakistan. Given their age, many surplus missiles are likely available at modest prices.

For states, turning anti-ship cruise missiles into ones that can attack targets on land is nothing new. The U.S. Navy has converted the Harpoon anti-ship cruise missile—which is exported to 24 nations—into the Stand-Off Land-Attack Missile (SLAM). Russia has done the same with its export family of Klub anti-ship missiles, one of which is being jointly produced by India and Russia under the name Brahmos. Yet, converting these modern anti-ship cruise missiles, which are densely packed with electronics and comparatively much smaller than the Seersucker/Silkworm family of missiles, offers little space for adding fuel to extend the range much beyond 100 km. Once the original autopilot and radar are removed from the Seersucker, however, there is significant space for additional fuel to propel the missile (assuming it uses a suitable turbojet engine) to around 1,000 km.[28]

Thus, two challenges stand in the way of converting an anti-ship cruise missile into a land-attack system: finding and installing a suitable turbojet engine to replace the existing liquid rocket engine and replacing the anti-ship guidance and control system with a land-attack one. Achieving the first challenge permits the missile to be launched from a ship lying significantly outside U.S. territorial waters.[29] The second is necessitated by the different challenges of guiding a cruise missile over the flat sea compared with the more variegated surface of the earth. The former seaborne setting means that the anti-ship cruise missile can use a simple autopilot for navigation and a terminal radar guidance system to seek out a large metal object (a ship). Were such a guidance system used over land, it would encounter difficulty hitting its intended target, one that would normally furnish far less contrast than a ship at sea. And because cruise missiles intentionally fly low to avoid detection, they must negotiate over and around varied terrain (mountains and man-made objects, for example) before they reach their intended targets. These demands dictate the use of a more sophisticated guidance and navigation system.

By no means should the challenges of converting a Seersucker into a land-attack cruise missile be seen as modest. Albeit limited in time, Iraq's experience with the process illustrates the demands. Called the *Jinin* project, Iraq conceived of a program to extend the range of the Seersucker to 1,000 km in November 2001.[30] The program benefited, in part, from Iraq's previously successful efforts to extend the Seersucker's range from about 100 km to 150 km.[31] The *Jinin* project was approved in June 2002, but for fear of being discovered by UN inspectors upon their return to Iraq, the country abandoned the project in December 2002. Yet, Iraqi engineers indicated that the program would require three-to-five years of development time, integrating the work of several research, development, and production organizations.

During the project's short-lived initial phase, the development team used computer simulations to assure the structural integrity and stability of the missile once it was fitted with a new propulsion system. Originally using turbine engines from surplus Russian Mi-8 helicopters, Iraqi engineers encountered problems achieving enough thrust and turned to another more advanced helicopter turbine engine. The senior program manager for the project said that a flight test could be conducted in three years. No work was accomplished on the guidance and control system, as the Iraqis initially believed that the existing HY-2 guidance system could be used in the *Jinin* project. They eventually did recognize that a foreign global positioning system (GPS) system would have to be acquired and integrated into a flight management system, but decided to await completion of flight tests to prove that the *Jinin*'s new propulsion system worked satisfactorily without destabilizing the vehicle's flight characteristics. This latter consideration was prompted by the realization that all of the internal rearrangements of the missile's subsystem components (perhaps even including additional fuel bladders) would likely affect flight control and stability.

Launching a modified Seersucker from a floating vessel presents yet another, if less difficult, problem. The missile would be nearly 8 meters long with a 2.4-meters-wide wingspan and a weight of nearly 3,000 kg. Although a standard 12-meter commercial shipping container would be more than adequate to house the missile, a small erector would have to be constructed to permit the missile to rise from the container for launching. Moreover, a solid rocket booster would be required to propel the missile from its erector to a height sufficient to commence flight via the turbojet engine.

Taken together, these tasks are beyond the capabilities of small terrorist groups, unless they could arrange various shortcuts amounting to virtually wholesale dependence on a foreign state's missile program. Moreover, there are numerous critical failure points along the path to completing this complex project, daunting even for state programs such as Iraq's and Iran's. It is far more likely that a terrorist group would choose significantly less sophisticated technical paths to develop a weapons delivery system.

Scenario 2: Converting a Small Airplane into a UAV for Weapons Delivery

Concern about the use of small UAVs as terrorist weapons began shortly after 9/11. By the following summer, Secretary of Defense Donald Rumsfeld reportedly sent the White House a classified memorandum warning about the spread of cruise missiles and UAVs and possible terrorist use of rudimentary technology to attack the homeland.[32] By early 2003, senior Bush administration officials told *Wall Street Journal* reporters that the President was keenly interested in intelligence reports that Iraq was developing small, easily transportable UAVs as weapons that could be shipped into the United States, or built here, and then be used to disseminate chemical or biological agents.[33]

Iraq admitted to the UN that it had sought to convert manned aircraft, such as the MiG-21, into a chemical-biological weapons (CBW) platform in the early 1990s.And there is indirect evidence that the L-29 trainer aircraft, which also was converted into a UAV, may have been intended for CBW delivery. But the Iraqi Survey Group found in 2003, after Operation Iraqi Freedom, that

Iraq's small UAV (known as Al Musayara-20 and thought to be capable of disseminating biological agents) had not yet been equipped to do so. However, the Al Musayara-20 had the range (beyond 500 kilometers), payload (20 kg), guidance (GPS-aided), and autonomy needed to be an effective biological delivery means if the Iraqi leadership had decided to pursue such a course.[34]

Although pre-war Iraq appears to have possessed the necessary skills and sufficient access to foreign assistance to develop such small UAVs for weapons delivery, it would be quite another matter for a terrorist group to accomplish the same task. Yet, with enough outside assistance and access to commercially available sub-components, it is at least conceivable—if not highly likely—that a terrorist organization could develop a much cruder version of Iraq's UAV exploits.

Acquiring an ultra-light or kit-built recreational airplane represents perhaps the most worrisome terrorist course of pursuing an unmanned attack weapon. The distinction between an ultra-light and larger kit-built airplanes is primarily one of size—according to FAA regulations, a powered ultra-light cannot exceed 254 pounds of empty weight, cannot carry more than 5 gallons of gasoline, nor exceed more than 55 knots at full power in level flight.

At first blush, one might assume that any terrorist group connected to al Qaeda would not require an unmanned vehicle. But attack effectiveness is in part dependent on the amount of payload that can be delivered. If a human is not piloting the aircraft, attack effectiveness could be greatly enhanced as the space otherwise devoted to a pilot and co-pilot can be given over to payload, conventional or otherwise.

Even an ultra-light aircraft could carry 150 or more pounds of payload, more than enough to mount a suitable sprayer for a biological agent or a load of conventional explosives. As previously noted, radiological dispersal becomes possible and potentially effective with a UAV over large urban areas, but only if the source comes in powdered form. As for conventional payloads, while a small UAV doesn't begin to compare with a jumbo jet's 60 tons of fuel, it is important to note that even gasoline, when mixed with air, releases 15 times as much energy as an equal weight of TNT.[35] Thus, even very small planes carrying an extra large fuel tank in place of a pilot could do significant damage in an urban setting.

Procuring a suitable aircraft is a vastly simpler task than turning it into an autonomous or even remotely controlled vehicle. By one accounting, the kit airplane market consists of nearly 100,000 copies of over 400 different designs from a worldwide list of manufacturers.[36] An alternative course of action would be to use mini-UAVs, or model airplanes that can either be remotely controlled from the ground or programmed for autonomous flight.[37] According to press accounts, al Qaeda considered using remotely controlled airplanes packed with explosives to attack the G-8 Summit in Genoa, Italy in 2001.[38] Working with smaller model aircraft surely reduces the chances of detection, but the limited amount of payload such models carry (a few pounds at most) is a limitation.

Kit airplanes, on the other hand, furnish between 150 and 300 pounds of payload and can be constructed in a single-car garage. Flying them autonomously (by programming routes and way points into a flight management computer), rather than controlling them via line-of-sight radio commands from the ground, presents the greatest danger of detection due to the greater possibility of an accident. However, kit planes do not require an airport for launch and return. They can operate from flat fields in remote areas, thus reducing, if not eliminating, the chances of detection.

Unlike the conversion of a first-generation, anti-ship cruise missile into a longer-range land-attack system, kit airplane conversion does not require a new propulsion system. The existing small reciprocating engine is sufficient to fly the craft to ranges of more than 500 miles. The stiffest

challenge lies with integrating and properly installing and testing the various components needed to manage stable autonomous flight to a precise point on the ground.

Achieving successful autonomous flight of a UAV is a daunting task for any terrorist group, even were they to have all the necessary technical skills. It would require at least two years of determined effort and some level of outside or foreign assistance. Although Iraq produced its own UAVs based on indigenous design plans, they still depended greatly on foreign assistance for access to British piston engines and commercial autopilots, servomechanisms, and guidance software.[39] Clearly, access to flight management systems not subject to export-control restrictions would save substantial development time and reduce the risk of catastrophic failure and detection.

Devices like the ones acquired by the Iraqis, providing complete autonomous operation, a GPS aided auto-pilot, and automatic takeoff and landing capabilities, cost in the neighborhood of $5,000. Still, the complexity and risks involved in achieving successful autonomous flight make the terrorist acquisition of a UAV a low-probability but high-consequence threat. This assessment could change due to the rapid pace of change in all the technologies relevant to unmanned flight. Several new aerospace firms have emerged in the United States and other countries over the last five years to sell all the necessary components and services required for converting manned aircraft into UAVs. Controlling the sale of these technologies to legitimate parties and countries will grow increasingly problematic without national and multinational attention to the export control challenges these technologies present.

International Responses to the Threat

However low the probability is of a terrorist group building a UAV for weapons delivery on its own, the potential consequences of such a development demand consideration of appropriate responses. Military and non-military measures alike could ameliorate the threat's emergence. Military improvements in defense against low-flying cruise missiles and UAVs—whether emanating from offshore or domestic points of origin—deserve immediate attention. The United States has deployed a rudimentary system to defend against a few intercontinental ballistic missiles, the return address of which will always be evident. Yet, expenditures to improve detection and interception of low-flying cruise missiles and UAVs pale by comparison. And because no amount of resources invested will produce a foolproof defense, it seems wise to also pursue improved nonproliferation policy. For example, national and multinational export controls could complicate easy access to UAV component technologies. The goal should be to create a mutually reinforcing set of responses to the threat of terrorist use of UAVs.

Improving Defenses Against UAVs

The technical, operational, and affordability challenges of defending against both offshore and domestic UAV threats are daunting. Consider, on the one hand, the requirements of defending against a low-flying cruise missile launched from a merchant ship. The first challenge is detecting a worrisome vessel from the many that come close to U.S. shores. At any one time in the Atlantic and Pacific oceans, there are roughly 100,000 vessels with enough space to house and launch a cruise missile.

Since 9/11, the U.S. Coast Guard has begun to pay much closer attention to foreign ships wishing to enter U.S. ports; such ships are now routinely inspected before reaching U.S. shores.[40] But prior to any inspection, a terrorist or rogue vessel could launch a subsonic missile flying at Mach 0.7 from a range of 500 km and reasonably expect it to escape detection.[41] If launched from 100 km offshore, the missile would need only about 7 minutes to reach its target, detection and capture would be more likely. Even if U.S. air defenses were not alert to the threat, the low-flying missile would fly under current ground-based warning radars that were designed to

deal with high-flying Soviet-era aircraft. Even were U.S. aircraft scrambled in enough time to react, current rules of engagement require a visual identification of the target to eliminate the possibility of shooting down a commercial aircraft. Thus, major improvements are needed across the so-called “kill chain”—cueing, surveillance, identification, engagement and kill assessment.

NORAD and the Army are currently studying the idea of an unmanned airship operating at an altitude of 65,000 feet and carrying sensors to monitor and detect offshore low-flying cruise missiles. Several airships would be needed together with fast-moving interceptors (perhaps a mix of ground-based and airborne ones) to cope with offshore threats. Perhaps 100 aerostats at an altitude of 15,000 feet could act as a complementary or alternative system of surveillance and fire control for an interceptor fleet.

Still, other problems remain. Some method of information relay is needed to warn to the Coast Guard of potentially hostile ships embarking from ports of concern. Missile threat sensor data must be capable of distinguishing between friendly traffic and enemy threats prior to threat engagement. Progress in national cruise missile defense will not be made without corresponding improvements in respective service programs, foremost among those being the implementation of the Single Integrated Air Picture (SIAP) program. Started in 1969—and still far from implementation—SIAP requires the merging of disparate service data links and target tracking radars to achieve a truly multiple-aspect view of enemy threats. Having one fully interoperable view of the air picture would accelerate decision-making in identifying friend from foe, a critical requirement given the dense commercial air traffic off the U.S. East and West coasts.

The question of affordability looms large. Even a limited defense against offshore cruise missiles would cost $30-40 billion. Yet, none of these costs or technical challenges pertains to improved defenses against domestic threats. In the aftermath of the September 11, 2001 terrorist attacks, NORAD had no internal air picture. Nor were its radar assets linked with those of the FAA, which controls internal US-air traffic. Progress towards making such linkages has occurred but major gaps remain, especially when dealing with the detection of low- and slow-flying air targets. One area showing particular promise, not least because of its potential affordability, is the exploitation of the nation’s existing high definition television infrastructure to detect, track, and classify such low-flying threats. Still, for the foreseeable future, the nation will remain ill-prepared to cope with such threats.

Improving Missile Nonproliferation Policy

The 34-nation Missile Technology Control Regime (MTCR) is the only extant multilateral, supply-side arrangement covering the transfer of missiles, related equipment, material, and technology relevant to WMD delivery. The MTCR found reason to worry about terrorist access to UAVs shortly after 9/11. At its 2002 annual plenary meeting in Warsaw, MTCR member states took the first step toward addressing possible terrorist use of UAVs and cruise missiles. Members committed to examine ways of limiting the risk of controlled items and their technologies falling into the hands of terrorist groups and individuals. Since announcing this commitment, the membership has revised its control list of systems and technologies, placing controls on UAVs designed or modified to dispense an aerosol of a volume greater than 20 liters. Yet, nothing thus far has been accomplished to address terrorist or state access to flight management systems capable of readily transforming manned aircraft into UAVs.

In January 2003, because of the growing concern about terrorist use of kit airplanes and other civil aircraft to create makeshift, lethal UAVs, the United States introduced an “anti-terrorism” proposal within the 34-nation Wassenaar Arrangement.[42] The proposal was designed to place export control reviews on all equipment, systems, and specially designed components that would enable airplanes to be converted to UAVs. But, because of its lack of specificity, the U.S. proposal received little support within the Wassenaar community.

At a March 2004 House Government Reform Committee hearing on ways of improving controls on cruise missiles and UAVs, the January 2003 “anti-terrorism” proposal to the Wassenaar Arrangement was raised during the question and answer period. In response to a query, Lisa Bronson, Director of the Defense Technology Security Administration and an undersecretary of defense, stated that the United States would reintroduce its proposal to control flight management within the Wassenaar Arrangement.[43] In light of the MTCR’s more aggressive interest in assuring that its controlled technologies do not fall into terrorist hands, the Wassenaar regime should investigate closely how it might improve controls on UAV guidance and navigation technologies. By comparison with Wassenaar, the MTCR possesses strong denial rules and no-undercut provisions (meaning if one member states denies a transfer, all must follow), making it the most effective multilateral mechanism to address the issue. The State Department’s Director of the Office of Chemical, Biological, and Missile Nonproliferation, Vann H. Van Diepen, indicated at the 2004 House hearing that his office planned to strengthen regulations dealing with missile guidance and propulsion.[44]

Conclusion

Although the United States alone cannot deal with the challenge of reducing terrorist access to technologies relevant to employing UAVs as weapons, it can exert its leadership role among key MTCR partners to convince the overall membership to reach consensus on this matter. Such a strengthening of export control regulations would make the prospect of transforming small manned aircraft into unmanned terror weapons substantially more difficult than it is today.

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Mr. Gormley served for 20 years with Pacific-Sierra Research (PSR), where he founded PSR’s Defense Policy Group. From 1989 to 1992, he directed PSR’s Washington Operations staff of 140 scientists, engineers, and policy analysts in providing analytical studies and applications software to government clients and served as a member of PSR’s Board of Directors. Mr. Gormley has frequently chaired or served on U.S. Department of Defense advisory committees, including chairing a 1997 Summer Study for the Undersecretary of Defense for Policy on Nuclear Weapons and the Revolution in Military Affairs. He frequently furnishes expert testimony to Congress and serves as a consultant to Sandia National Laboratories and The RAND Corporation, among others. He has also been a Visiting Scholar at the Geneva Center for Security Policy, Geneva, Switzerland.

Before joining PSR in 1979, he was head of foreign intelligence at the U.S. Army’s Harry Diamond Laboratories in Washington, D.C. Mr. Gormley received a BA and MA in history from the University of Connecticut in 1965 and 1966 and attended Office Candidate School at Aberdeen Proving Grounds, Maryland, where he was commissioned a Second Lieutenant in the U.S. Army Ordnance Corps, serving on active duty from 1966 to 1969. He has published three books, including *Dealing with the Threat of Cruise Missiles* (Oxford: Oxford University Press, 2001) and authored numerous contributions to leading journals and newspapers internationally.

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5. Equally important, though not the central focus of this article, is the matter of access to, or development of, chemical, biological, or radiological weapons.

6. See Steven Simon and Daniel Benjamin, "America and the New Terrorism," *Survival* 42, no. 1 (Spring 2000), 59-75. For follow-up debate on the subject, see "America and the New Terrorism: An Exchange," *Survival* 42, no. 2 (Summer 2000), 156-72.

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9. For details on Mahmoud's testimony and activities, see Daniel Benjamin and Steven Simon, *The Age of Sacred Terror* (New York: Random House, 2002), 203-205.

10. "Hijack Suspect Visited Crop Dusting Airfield," *ABCNEWS.com*, September 23, 2001.

11. Pete Yost, "Crop Dusters Grounded in FBI Probe," *Associated Press*, September 24, 2001.

12. Mark Steyn, "Mohammed Atta and His Federal Loan Officer," *National Post* (Toronto), June 1, 2002.

13. Interview with a former biological weapons scientist in the U.S. program on August 18, 1999. Balloon delivery might be able to achieve great ranges if launched into the upper atmosphere, but the corresponding uncertainty of disseminating its payload with any terminal effectiveness is enormous.

14. Edward Eitzen, "Chapter 20—Use of Biological Weapons," in *Medical Aspects of Chemical and Biological Warfare* (Washington, DC: Walter Reed Army Medical Center, 1997), 440-442.

15. This is demonstrated through extensive modeling and simulation. Private communication with Dr. Gene E. McClellan, Pacific-Sierra Research Corporation, Arlington, Virginia, August 22, 1997.

16. Most other radioactive sources of concern, such as cobalt-60 and iridium-192, are solid materials. I am grateful to my CNS colleague, Dr. Charles Ferguson, for bringing these points to my attention. Also see Charles D. Ferguson, Tahseen Kazi, and Judith Perera, "Commercial Radioactive Sources: Surveying the Security Risks," Occasional Paper No. 11, Center for Nonproliferation Studies, January 2003.

17. Even U.S. missile defense systems, such as Patriot, which claim to have capabilities against ballistic and cruise missiles, as well as aircraft, have severe shortcomings detecting and successfully prosecuting intercepts against cruise missiles and UAVs. For example, in Operation Iraqi Freedom, Patriot batteries performed well against Iraqi ballistic missiles, but not against ancient and low-flying Silkworm anti-ship missiles, which went completely undetected. Moreover, two Iraqi ultra-light aircraft managed to fly directly over the 3 rd Infantry Division's logistical encampment and disappeared before orders could be arranged to fire at them. Even the use of expensive airborne reconnaissance systems such as AWACS would not help. Their radars intentionally eliminate slow-flying targets on or near the ground in order to prevent their data processing and display systems from being overtaxed. Lots of human eyes stand as perhaps the most effective means of detecting such slow-flying threats. For more on the Iraqi cruise missile attacks, see Dennis M. Gormley, "North Korean Cruise Missile Tests—and Iraqi Cruise Missile Attacks—Raise Troubling Questions for Missile Defense," Center for Nonproliferation Studies. On the ultra-light incident, see Sean D. Naylor, "Iraqi Ultralights Spotted over U.S. Troops," *Army Times*, March 29, 2003.

18. Spencer S. Hsu, "Plane That Caused Capitol Evacuation Nearly Shot Down," *Washington Post*, July 8, 2004, A1.

19. Sara Kehaulani Goo, "Airspace Violations Prompt Rule Review," *Washington Post*, July 6, 2005, A6.

20. *Ibid*.

21. Bruce Simpson's website is www/interestingprojects.com/cruisemissile/.

22. "DIY Cruise Missile Thwarted," *BBC News Online*, December 9, 2003. According to Simpson, Iran was among a potential list of buyers of his detailed technical journals offered on his website under a subscription option.

23. For a brief analysis of cruise missile defenses for dealing with such threats, see Dennis M. Gormley, "Missile Defence Myopia: Lessons from the Iraq War," *Survival* 45, no. 4 (Winter 2003-04), 61-86.

24. David Pugliese, "Terrorist are Training on Hang-Gliders, Experts Warn," *Calgary Herald*, March 26, 2004, 1.

25. Daniel Benjamin and Steven Simon, "The Worse Defense," *The New York Times*, February 20, 2003, 31.

26. See Lothar Ibrugger, "Report of the NATO Parliamentary Assembly, Subcommittee on the Proliferation of Military Technology, Missile Defences and Weapons in Space," November 2004.

27. HY-2 is the Chinese designation for what the West (and NATO) refers to as the Seersucker cruise missile. The HY-1, an earlier version, is referred to in the West as the Silkworm. All too frequently, Western media uses the Silkworm appellation for both the HY-1 and HY-2 anti-ship cruise missiles. See www.fas.org/man/dod-101/sys/missile/row/hy-1.htm for details about the HY-2 Seersucker and www.fas.org/man/dod-101/sys/missile/row/hy-1.htm for information on the HY-1 Silkworm. Both missiles are candidates for conversion to a land-attack cruise missile.

28. For more on extending a cruise missile's range, see Dennis M. Gormley, "Dealing with the Threat of Cruise Missiles," *Adelphi Paper* 339 (Oxford: Oxford University Press, 2001).

29. The UN-sponsored Law of the Sea Treaty specifies 12 nautical miles (or 22.2 km) as a nation's territorial waters, but in 1999 the President proclaimed that federal agencies would enforce American law up to twice the distance, or 39 km. According to Commander R.B. Watts, USCG, since 9/11 much closer scrutiny is made of suspect vessels wishing to enter U.S. waters, and the Coast Guard routinely inspects such vessels before they are allowed to enter a U.S. port. Thus, standing considerably outside of U.S. waters would offer much greater prospect of avoiding detection prior to launch. See R.B. Watts, "Fight Them Forward," in the *Strategic Insights* electronic journal produced by the Center for Contemporary Conflict at the Naval Postgraduate School, July 2005.

30. All details discussed about the *Jinin* project are taken from the "Comprehensive Report of the Special Advisor to the DCI on Iraq's WMD," vol. 2, otherwise known as the "Duelfer Report."

31. According to the Duelfer Report, Iraq's extended range HY-2 was flown to a distance of 168 km, but was adjusted to keep it within the UN-restricted range limit of 150 km because this program was declared by Iraq in 1996. One Iraqi engineer commented to the Survey Group that Iraq targeted Kuwait during the 2003 war with these missiles. However, no mention is made whether or not Iraq succeeded in acquiring and installing a modernized land-attack guidance and control system prior to use in 2003. For an analysis of the Seersucker's use in Operation Iraqi Freedom, see Gormley, "Missile Defence Myopia," *Op. Cit.*

32. Bradley Graham, "Cruise Missile Threat Grows, Rumsfeld Says," *Washington Post*, August 18, 2002, A1.

33. "At Davos, Powell Pushes Back Against Resistance Over Iraq," *Op. Cit.*

34. This course of action would have required the installation of a suitable BW dispenser. The Iraqi Survey Group also reported that the Republican Guards had directed that some Al Musayara-20s be converted in weapons-carrying UAVs (with conventional explosives). See "Duelfer Report," *Op. Cit.*

35. Richard A. Muller, "The Cropdusting Terrorist," *Technology Review*, March 11, 2002.

36. This accounting was accomplished by Dr. Gregory DeSantis, a private consultant and colleague of the author, based on a review of the kit airplane literature during 2001.

37. For an analysis see Eugene Miasnikov, *Threat of Terrorism Using Unmanned Aerial Vehicles: Technical Aspects* (Moscow: Center for Arms Control, Energy and Environmental Studies, Moscow Institute of Physics and Technology, 2005).

38. Michael Gips, "A Remote Threat," *Security Management Online*, October 2002. Gips also notes that one security expert, a former intelligence officer, Louis Mizell, has recorded 43 cases

involving 14 terrorist groups where remote-control delivery systems were “either threatened, developed, or actually utilized.”

39. See: “Duelfer Report," *Op. Cit.* The Iraqi ambassador to Russia purchased GPS components for their UAV program from Russian technicians working at their homes, supposedly without the knowledge of the Russian government. Iraq also reportedly obtained four Micropilot MP2000 and two 3200VG autopilots from an Australia-based procurement agent.

40. Watts, *Op. Cit.*

41. Sitting at a range of 500 km from U.S. shores, a merchant ship could operate in an area exceeding 390,000 square km. See Col. Charles E. Lambert, “The Cruise Missile Conundrum.”

42. The Wassenaar Arrangement attempts to achieve transparency and greater responsibility in transfers of conventional arms and dual-use goods and technologies (including UAVs with very short ranges, making it much more extensive than that of the Missile Technology Control Regime’s range of at least 300km). See Dennis M. Gormley and Richard Speier, “Controlling Unmanned Air Vehicles: New Challenges,” *Nonproliferation Review*, Summer 2003, 66-79, for a review and analysis of recent nonproliferation initiatives, including the January 2003 U.S. antiterrorism proposal dealing with converting airplanes into UAVs.

43. Robert Wall, “U.S. Intends to Enhance Controls Over Missile and UAV Technologies,” *Aviation Week & Space Technology*, March 15, 2004, 25.

44. *Ibid.*